ASTRONOMICAL PHENOMENA FOR THE WEEK 1887 *APRIL* 17-23

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on April 17

Sun rises, 5h. 2m.; souths, 11h. 59m. 33·9s.; sets, 18h. 57m.; decl. on meridian, 10° 28′ N.: Sidereal Time at Sunset, 8h. 39m.

Moon (New on April 23) rises, 3h. 3m.; souths, 7h. 53m.; sets, 12h. 49m.; decl. on meridian, 14° 2′ S.

Planet	Rises h. m.	Souths h. m.	Sets h. m.	Decl. on meridian ° ′
Mercury	4 29	10 22	16 15	2 9 S.
Venus	6 6	14 5	22 4	20 54 N.
Mars	5 8	12 7	19 6	10 45 N.
Jupiter	19 11*	0 20	5 29	10 37 S.
Saturn	9 20	17 29	1 38*	22 26 N.

* Indicates that the rising is that of the preceding evening and the setting that of the following morning.

April	h.	
18	21	Mercury at greatest elongation from the Sun, 27° west.
20	21	Mercury in conjunction with and 0° 31′ north of the Moon.
21	11	Jupiter in opposition to the Sun.

Variable Stars

Star	R.A. h. m.	Decl. ° ′		h. m.	
U Cephei	0 52·3	81 16 N.	Apr. 19,	4 42	*m*
Algol	3 0·8	40 31 N.	,, 17,	20 45	*m*
δ Libræ	14 54·9	8 4 S.	,, 20,	21 3	*m*
			,, 23,	4 54	*m*
U Coronæ	15 13·6	32 4 N.	,, 17,	5 0	*m*
U Ophiuchi	17 10·8	1 20 N.	,, 18,	4 10	*m*
			and at intervals of	20 8	
W Sagittarii	17 57·8	29 35 S.	Apr. 20,	22 0	*M*
β Lyræ	18 45·9	33 14 N.	,, 20,	0 0	*M*
S Vulpeculæ	19 43·8	27 0 N.	,, 20,		*m*
S Sagittæ	19 50·9	16 20 N.	,, 18,	22 0	*m*
δ Cephei	22 25·0	57 50 N.	,, 20,	4 0	*M*
			,, 23,	22 0	*m*

M signifies maximum; *m* minimum.

Meteor-Showers

The most interesting shower of the week is that of the *Lyrids*, April 18-20, R.A. 268°, Decl. 33° N. Other showers are as follows:—Very slow meteors from a radiant between Boötes and Virgo, R.A. 213°, Decl. 9° N.; very swift meteors from near π Herculis, R.A. 255°, Decl. 37° N., and from Vulpecula, R.A. 299°, Decl. 24° N.

VALENCY AND RESIDUAL AFFINITY[1]

I.

IN my address to the Chemical Section of the British Association at Aberdeen, I specially called attention to the "affinity" of *negative* elements—chlorine, oxygen, sulphur, &c.—for negative elements; and I sought to show that the formation of so-called *molecular compounds* is largely, if not entirely, an outcome of this peculiarity of negative elements. I also ventured to suggest "that in electrolysing solutions, the friction arising from the attraction of the ions for each other is perhaps diminished, not by the mere mechanical interposition of the *neutral* molecules of the solvent—in the manner suggested by F. Kohlrausch—but by the actual attraction exercised by these molecules upon the negative ion in virtue of the affinities of the negative radicles." In this passage I but vaguely hinted at a modification of the current theory of electrolysis which had occurred to me: as further consideration of the question, especially of Ostwald's electro-chemical studies, has strengthened my views, I am led to think that it may be justifiable to submit them for discussion.

It is usual to divide bodies into three classes according to the mode in which they are acted on by an electromotive force: metals forming one class, electrolytes a second, and dielectrics a third. In making this division, perhaps the fact is not sufficiently borne in mind that some compounds—silver chloride, for example—are *per se* electrolytes, while others—such as hydrogen chloride and water—are *individually* dielectrics, but behave as electrolytes when conjoined. On this account, it appears to me desirable to distinguish between—

(*a*) *Metals.*

(*b*) *Simple* electrolytes—compounds like silver chloride which in the pure state are electrolytes.

(*c*) *Pseudo*-dielectrics — compounds like water, hydrogen chloride, and sulphuric acid, which behave as dielectrics when *pure*, but as electrolytes when mixed with other members of their own class. Conducting mixtures of members of this class may conveniently be termed *composite electrolytes.*

(*d*) Dielectrics.

Simple Electrolytes.—It is undoubtedly a fact that only a limited number of binary compounds are simple electrolytes; and it is especially noteworthy that, with the single doubtful exception of liquefied ammonia, no hydrogen compound—whether binary or of more complex composition—can be classed with the simple electrolytes. Indeed, all the simple electrolytes with which we are acquainted are either compounds, such as the *metallic* chlorides; or *metallic* salts—nitrates, sulphates, &c. Including metallic chlorides and their congeners and the corresponding oxides and hydroxides among salts—regarding water as an acid, in fact—and denying the title of salts—hydrogen salts—to the acids, Hittorf's proposition (*Wied. Ann.*, 1878, iv., p. 374), "Electrolyte sind Salze" may be safely upheld. But only some of the binary metallic salts are electrolytes: beryllium chloride, for example, belongs to the class of "pseudo-dielectrics" (Nilson and Petterson, *Wied. Ann.*, 1878, iv., p. 565; Humpidge, Phil. Trans., 1883, p. 604); and in the case of those elements which readily form two classes of salts—so-called *ous* or *proto*-salts and *ic* or *per*-salts, the *ous* compounds alone appear to be electrolytes.

It is highly remarkable that whereas fused silver chloride is easily decomposed on passage of a current of low electromotive force, hydrogen chloride is a "pseudo-dielectric" which forms when coupled with the "pseudo-dielectric" water a readily conducting "composite electrolyte"; while mercuric chloride conducts with great difficulty—possibly not at all when pure—not only in the fused state, but even when coupled with water. No explanation of these facts seems to be afforded by thermo-chemical data.

The consideration of these and other similar cases, I think, can but lead to one conclusion: that electrolysability is conditioned both by the nature of the elements in the compound and its molecular structure.

The remarkable difference in the electrical behaviour of two compounds of the same element, such as stannous chloride, in which the ratio of tin to chlorine atoms is as 1 to 2, and stannic chloride, in which Sn : Cl = 1 : 4—the one being a simple electrolyte, the other a pseudo-dielectric, if indeed it be not a dielectric—would appear almost to justify the conclusion that in the case of per-salts such as stannic chloride the metal is, as it were, enveloped in a non-conducting sheath of the negative radicle. But whether this be so or not, if—as appears to be the case—all simple electrolytes are *metallic* compounds, and if only proto-salts are electrolytes, may it not be that electric conduction in simple electrolytes is of the nature of ordinary metallic conduction, differing from it only in the circumstance that the compound is decomposed as a consequence of the passage of the current?

This would lead to the conception of an electrolyte as being a metallic compound of such elements, and so constituted, that electric conduction may take place through its mass in a manner similar to that in which it takes place through a mass of metal: in fact, through the agency of its metallic atoms. On this view, it is essential that the metallic atoms in the molecules comprising a mass of an electrolyte should be in proximity—as they probably are in proto-salts, but not in many per-salts. The conductivity of two-metal alloys is in many cases much less than that of either of the contained metals: for example, the conductivity of the alloy $SnCu_4$ is about one-fourth that of tin and about one-thirtieth that of copper. The specific conductivity of metals may, therefore, be much reduced by association with one another; and this being the case, it appears probable that the specific conductivity of a metal would be still more reduced by association with a non-metal, and that if the metal were one of low specific conductivity, it might thus practically become altogether deprived of conducting power: perhaps the "exceptional" behaviour of mercuric and beryllium chlorides is to be explained by considerations such as these.

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[1] Revision and extension of a paper by Prof. H. E. Armstrong, F.R.S., communicated to the Royal Society last year.

To discuss such questions at all satisfactorily, however, we require to know much more of the electrical behaviour of *pure* fused salts. It is surprising how little accurate knowledge we possess on this subject.

Composite Electrolytes.—I assume it to be admitted that neither water nor liquid hydrogen chloride, for example, is an electrolyte, although an aqueous solution of hydrogen chloride conducts freely, and is electrolysed by an electromotive force of but little more than a volt.

The theory put forward by Clausius in 1857 in explanation of electrolysis (cf. Clerk Maxwell's "Elementary Treatise on Electricity," p. 104), has been widely accepted by physicists; but it appears to me that, on careful consideration of the evidence, and especially of recent exact observations on conditions of chemical change, it must be admitted, as I have elsewhere contended (B. A. Address), that proof is altogether wanting of the existence of a condition such as is postulated by Clausius. Moreover, it has been shown by Hittorf that cuprous and silver sulphides, and by F. Kohlrausch that silver iodide, all undergo electrolysis in the *solid* state: the partisans of the dissociation hypothesis would, I presume, scarcely contend that it is easily applicable to such cases as these. It also does not appear to afford any explanation of the *abrupt* change in conductivity which occurs in solid silver iodide and sulphide as the temperature is raised; nor of the peculiar variation in conductivity which is observed on diluting sulphuric acid with water.

Again, I venture to think that the conductivity of a *mixture* of compounds which themselves have little or no conducting power is accounted for in but an unsatisfactory and insufficient manner by the hypothesis put forward by F. Kohlrausch (*Pogg. Ann.*, 1876, clix., p. 233); there appears to be *far too great a difference* in the behaviour of the pure compounds, water and liquid hydrogen chloride for example, and of a mixture—no decomposition apparently of either *compound* being effected by any electromotive force short of that which produces disruptive discharge, although the *mixture* of the two will not withstand an electromotive force of little more than a volt. Influenced by these considerations, I am led to conclude that there is no satisfactory evidence that the constituents of the electrolyte either are free prior to the action of the electromotive force, or are primarily set free by the effect produced by the electromotive force upon either member *separately* of the *composite* electrolyte; but that an additional influence comes into play, viz. that of the one member of the composite electrolyte upon the other while both are under the influence of the electromotive force. This influence, I imagine, is exerted by the negative radicle of the other member. Assuming, for example, that in a solution of hydrogen chloride in water the oxygen atom of the water molecule is straining at the chlorine atom of the hydrogen chloride molecule, if when subjected to the influence of an electromotive force the molecules are caused to flow past each other—the phenomena of electric endosmose may be held to afford evidence that in composite electrolytes the molecules are thus set in motion—it is conceivable that this influence, superadded to that of the electromotive force upon the electrolyte, may bring about the disruption of the molecule and conduction: in short, that a state may be induced such as Clausius considers is the state prior to the action of the electromotive force.

A large amount of most valuable information on the connexion of dilution and electrical conduction in aqueous solutions has been recently published by Arrhenius, Bouty, F. Kohlrausch, and Ostwald. In his most recent paper, Ostwald (*Journal für praktische Chemie*, 1885, xxxii., p. 300) has given the results of his determinations of the *molecular conductivity* in the case of no less than about 120 different acids; and it appears to me that many—indeed all—of his observations afford most distinct evidence in favour of the view I have expressed above. The general result of his investigation is that the molecular conductivity increases with dilution: in other words, that the dissolved substance exercises a greater specific effect, finally attaining a maximum; it then diminishes, but he believes this to be due to impurities in the water, especially to neutralisation of the acid by traces of ammonium carbonate. The maximum, he appears to think, would be the same for all acids if the dilution could only be pushed far enough: in the case of monobasic acids it is about 90 (arbitrary units); it is twice this in the case of dibasic, thrice in the case of tribasic, and so on.

I will quote first his results in the case of solutions of hydrogen chloride, bromide, iodide, fluoride, and silicon fluoride. v is the volume in litres which contains a weight in grammes corresponding to the formula of the dissolved substance—36·4 grammes of hydrogen chloride, for example.

v	HCl	HBr	HI	HF	H_2SiF_6
2	77·9	80·4	80·4	...	47·81
4	80·9	83·4	83·2	6·54	57·29
8	83·6	85·1	84·9	7·59	62·20
16	85·4	86·6	86·4	10·00	67·08
32	87·0	87·9	87·6	13·14	71·52
64	88·1	88·9	88·7	17·38	75·61
128	88·7	89·4	89·4	23·11	79·22
256	89·2	89·6	89·7	30·30	83·39
512	89·6	89·7	89·7	39·11	91·62
1024	89·5	89·5	89·3	49·49	109·5
2048	89·5	88·9	89·0	59·56	144·0
4096	88·6	87·6	87·8	69·42	187·1
8192	...	...	...	...	226·6
16384	...	...	...	...	258·6
32768	...	...	...	...	282·6

It will be observed that hydrogen chloride, bromide, and iodide practically behave alike; the numbers for the chloride are, however, slightly lower than those for the bromide and iodide, and the maximum is not reached quite so soon in the case of the chloride. Hydrogen fluoride is altogether different; its molecular conductivity is exceedingly low to begin with, and is considerably below the maximum even when $v = 4096$. But I would call special attention to the numbers for hydrogen silicon fluoride, which is commonly regarded as a dibasic acid: at first, as Ostwald says, it behaves as a monobasic acid of moderate strength—iodic acid, for example; but the maximum for monobasic acids being exceeded, the molecular conductivity increases more and more rapidly, ultimately exceeding the treble value, 270. It must be supposed that it undergoes decomposition in accordance with the equation—

$$H_2SiF_6 + 2H_2O = SiO_2 + 6HF.$$

The noteworthy point is *the large excess of water* required to initiate this change: when $v = 16$ the solution contains less than 1 per cent. H_2SiF_6, and at this point, according to Ostwald, decomposition probably begins; but that it is far from complete even when a very much larger excess is present is evident from the fact that the maximum when $v = 32,768$ is 282 and not above 400.

Now it is well known that hydrogen chloride, bromide, and iodide are, practically speaking, perfect gases under ordinary circumstances: in other words, masses of these gases would mainly consist of molecules such as are represented by the formulæ HCl, HBr, and HI. It has been proved, however, by Mallet, that hydrogen fluoride at temperatures near to its boiling-point mainly consists of molecules of the formula H_2F_2. In the aqueous solution the molecules would be brought more closely together, and therefore it is probable that, even in the case of hydrogen chloride, bromide, and iodide, a certain proportion of more complex molecules would result: the relatively high boiling-point of hydrogen fluoride (19°·4) renders it probable that in the liquid state this compound would at least partially consist of molecules more complex even than is represented by the formula H_2F_2. On the hypothesis put forward in this paper, the influence exercised by the one member of the composite electrolyte upon the other member during electrolysis is at all events mainly exercised by their respective negative radicles, and the extent of the influence thus mutually exerted by these radicles would depend on the extent to which they are still possessed of "residual affinity." If the hydrogen chloride, bromide, and iodide are present chiefly as simple molecules, they should exert, *ab initio*, almost the full effect which they are capable of exerting; and the chief effect of dilution being to decompose the more complex molecules, conductivity should increase to but a slight extent if the extent to which simplification can take place be but small On the other hand, if owing to the formation of molecular aggregates the residual affinity be more or less exhausted, the initial conductivity will be low, and it will increase on dilution only in proportion as these aggregates become broken up.

It appears to me that the behaviour of the four hydrides under discussion is absolutely in accordance with these requirements of the hypothesis. Evidence of the same kind is afforded by all of Ostwald's results.

The behaviour of solutions of neutral metallic salts on dilution is very similar to that of acids; abundant proof of this is afforded especially by F. Kohlrausch's refined measurements, of which an account has recently been published (*Wied. Ann.*, 1886, xxvi., p. 162). I venture to think that a similar explanation to that above given for oxides will apply to salts; and also that the low molecular conductivities of salts as compared with corresponding acids may be regarded as confirmatory of my hypothesis. I think we must admit that the metals generally have less affinity than hydrogen for negative radicles; if this be granted, we have at once an explanation of the fact that metallic salts are mostly fixed solids, few of which are more than moderately soluble in water while many are very difficultly soluble or insoluble, whereas the corresponding acids are mostly volatile and readily soluble in water, if not miscible with it in all proportions. The affinity of the negative radicles being less exhausted by union with metals than with hydrogen, the fundamental molecules of salts are more prone to unite together to form complex aggregates.

Arrhenius, who has studied the electrical behaviour of solutions of a number of salts, attributes the change observed in molecular conductivity on dilution—as I have done—to molecular changes; but his deductions are all based on the acceptance of the Williamson-Clausius hypothesis of dissociation.

My hypothesis would also account for the increase in conductivity in composite electrolytes with rise of temperature. It is true that as temperature rises the influence which individual molecules exert upon each other would be lessened; but, on the other hand, the complex aggregates would become more and more completely resolved into their fundamental molecules, the velocity of molecular motion would increase, and the tendency of the constituent atoms to remain united would be lessened. From this point of view the determination of the coefficient of change of conductivity with temperature in the case of substances whose molecular conductivity increases considerably on dilution in comparison with allied compounds which exhibit only a slight variation in molecular conductivity on dilution affords an interesting subject for investigation. F. Kohlrausch has already pointed out (*Pogg. Ann.*, 1875, cliv., p 236) that in the case of all neutral salts, "der Einfluss der Temperatur auf das Leitungsvermögen mit wachsender Verdünnung sich Anfangswerthen nähert, die zwischen engen Gränzen liegen;" and the experiments of F. Kohlrausch and Nippoldt on solutions of sulphuric acid (*ibid.*, 1869, cxxxviii., p. 286) show that the resistance diminishes to a much greater extent for equal increments of temperature in concentrated than in dilute solutions.

As concentrated solutions would be richer in complex aggregates than dilute solutions, these results are in entire accordance with my hypothesis: it does not appear to me that they can be satisfactorily interpreted in terms of the dissociation hypothesis.

In cases where the influence of the one member of the composite electrolyte upon the other is but slight, it may happen that the effect of temperature in diminishing this influence will outweigh that due to molecular simplification, and that, in consequence, conductivity will diminish with rise of temperature; a mixture of alcohol and ether would appear to furnish an example of this kind: according to Pfeiffer's recent observations (*Wied. Ann.*, 1886, xxvi., p. 216), such a mixture behaves as a metallic conductor of very high resistance.

The increase in conductivity of graphite and gas-retort carbon on heating, and the effect of light on the conductivity of (? impure) selenium and some other substances (Shelford Bidwell, Phys. Soc. Proc., pp. 122, 256), appear to me to be also explicable on the assumption that in all these cases we are dealing with composite electrolytes.

If any further proof be needed of an intimate connexion between molecular composition and electrolytic conduction, it is most conclusively afforded, I think, by the observations of W. Kohlrausch on chloride, bromide, and iodide of silver (*Wied. Ann.*, 1882, xvii., p. 642). In the fused state, these compounds are better conductors than the most highly-conducting mixture of sulphuric acid and water, which of all liquids is the best conductor at ordinary temperatures, but when the change from the fused to the solid state sets in the resistance of both silver chloride and bromide suddenly increases. No such change takes place, however, in the case of silver iodide. This iodide fuses at 557° according to Rodwell, but at about 540° according to Kohlrausch; its electrical resistance increases only gradually after it has become solid, and remains almost a linear function of the temperature during an interval of 400°, until suddenly at near 150° it increases enormously, this change taking place at the moment when, according to Rodwell (Phil. Trans., 1882, p. 1153), it passes from the transparent, plastic, amorphous solid to the opaque, crystalline state, the volume increasing considerably. Kohlrausch has proved most conclusively that the solid iodide may undergo electrolysis. It would seem that almost immediately after solidification in the case of silver chloride and bromide practically the whole mass consists of complex aggregates so constituted as to be exceedingly bad conductors, but that such aggregates are formed much less readily by silver iodide.

(*To be continued.*)

THE MAZAPIL METEORIC IRON[1]

AMONG the large number of meteoric irons which have been described, only eight[2] are recorded as having been seen to fall. It is my privilege to be able to add a ninth fall to this short list, and one which may prove to be of exceptional scientific importance. This mass of meteoric iron I received in August last as a gift from my friend, Prof. José A. y Bonilla, Director of the Astronomical Observatory at Zacatecas, Mexico. He stated that it was *seen to fall* at about 9 p.m. on November 27, 1885, during the periodical star-shower of the "Bielids." Such is the unique interest of this meteorite, as shown by its history, that I have delayed announcing it until the evidence of its fall had been substantiated as thoroughly as possible.

The general freshness of surface, which shows very perfectly the flow of the melted crust; the presence of unusually large nodules of a very compact graphite; the very slight superficial oxidation, and its dissimilarity to other meteorites of the region, are all interesting features of this iron, and serve to confirm the statement of its recent fall. When received it weighed about 3950 grammes. Its present weight is 3864 grammes, or 10 pounds 4¼ ounces, troy. Its greatest length is 175 millimetres as measured diagonally across the mass. In its thickest part it measures about 60 millimetres. It could be described as a flat irregular mass, covered with deep depressions, having a smooth surface (see Fig. 1).

The evidence of the fall is set forth in the following communication from Prof. Bonilla.

(Translation).—"It is with great pleasure that I send to you the uranolite which fell near Mazapil, during the night of November 27, 1885. That you may the better appreciate the great scientific interest which this uranolite possesses, I will state that everything points to the belief that it belongs to a fragment of the comet of Biela-Gambart, lost since 1852. I here give you the history of this celestial wanderer. On December 2 (1885) I received, to my great delight, from Eulogio Mijares, who lives on the Conception Ranch, 13 kilometres to the east of the town of Mazapil, a uranolite, which he saw fall from the heavens, at nine o'clock on the evening of November 27, 1885. The fall, simply related, he tells as follows, in his own words:—

"'It was about nine in the evening when I went to the corral to feed certain horses, when suddenly I heard a loud hissing noise, exactly as though something red-hot was being plunged into cold water, and almost instantly there followed a somewhat loud thud. At once the corral was covered with a phosphorescent light and suspended in the air were small luminous sparks as though from a rocket. I had not recovered from my surprise when I saw this luminous air disappear and there remained on the ground only such a light as is made when a match is rubbed. A number of people from the neighbouring houses came running toward me and they assisted me to quiet the horses which had become very much excited. We all asked each other what could be the matter, and we were afraid to walk in the corral for fear of getting burned. When, in a few moments, we had recovered from our surprise, we saw the phosphorescent light disappear, little by little, and when we had brought lights to look for the cause, we found a hole in the ground and in it a ball of fire. We retired to a distance, fearing it would explode

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[1] From the March number of the *American Journal of Science*, vol. xxxiii. pp. 221–26.

[2] Agram, Croatia, May 26, 1751; Charlotte, Dickson Co., Tenn., August 1, 1835; Braunau, Bohemia, July 14, 1847; Tabarz, Saxony, October 18, 1854; Victoria West, Africa, in 1862; Nejed, Arabia, spring of 1865; Nedagolla, India, January 23, 1870; Rowton, Shropshire, England, April 20, 1876. See the Catalogue of the Meteorites in the Mineral Department of the British Museum, by L. Fletcher, p. 42.